FIRST-ORDER PROPERTIES OF CHONDRITIC CLUSTER IDPs BASED ON DATA FROM THE NASA/JSC COSMIC DUST CATALOGS. Frans J.M. Rietmeijer, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 97131, USA.

Since the early days of the NASA/JSC Cosmic Dust Program it was appreciated that an IDP on a collector surface could be a fragment of a cluster particle but there was no unambiguous cluster definition. The designation of an individual IDP as a fragment is still not fully reliable. A survey of nonspherical chondritic IDPs showed that cluster IDPs are common albeit that they may be underestimated on small area collectors [1]. Recently, the wide variety of textures, minerals and chemical properties of individual IDPs believed to be fragments of a cluster IDP was submitted as evidence for the existence of an asteroidal regolith [2]. To advance our knowledge of small Solar System bodies it is a prerequisite that we are able to recognise cluster IDPs to define the nature of the meteroid flux in this size range and their source(s). To explore the first-order properties, I surveyed the abundances, sizes and morphology of nonspherical chondritic IDPs from the NASA/JSC Cosmic Dust Catalogs 1-14 (except vol. #6). Earlier work showed that the cosmic dust collection is well suited for statistical analyses of trends in IDP abundances [1] and types [3]. Data selection and reduction procedures, including a definition of background (BKG) levels, are presented in a companion abstract [1].

RESULTS. Many IDPs are listed as fragments of clusters [Note: I also accepted the designation "associated with" to indicate a cluster]. The "unbound" nonspherical chondritic IDP abundances are calculated once all IDPs listed as cluster fragments are removed from the database. The resulting BKG levels for these "unbound" IDPs are 0.16 p h^{-1} (2-9 µm) and 0.24 p h^{-1} (>9-19 µm). The BKG for cluster IDPs (assumed here to be >19 µm) is 0.08 p h^{-1}. These data are used to obtain the nomalized "unbound" IDP and cluster abundances for each collector [Fig. 2] The low abundant "unbound" IDPs >19 µm are omitted from this analysis [1]. It shows a dramatic decrease of "unbound" IDPs (2-9 µm) on LACs and U2022. In fact, IDPs < 9 µm mostly occur in clusters. Cluster IDPs are apparently most abundant on the LACs but further investigations of collection and curation procedures are necessary to quantify these distributions [1].

AVERAGE Cluster IDP Properties. Using data from LACs only, fragments (formerly IDPs) of the *average cluster IDP* in the 2-9 µm size range include 80% chondritic IDPs, 12% silicate and 7% FeS particles; ~16% of chondritic fragments are chondritic porous (CP) IDPs and ~84% are chondritic filled (CF) IDPs [Table 1]. In the average cluster IDP about 67% of carbon-rich fragments are 2-9 µm in size, 28% are >9-19 µm, and only 5% are >19 µm. These carbon-rich, nonspherical chondritic IDPs are recognised by a high bremsstrahlungs background in their EDS spectrum. About 80% of carbon-rich IDPs (2-9 µm) on the LACs are in cluster IDPs. Also IDPs (2-9 µm) occur in equal abundances as fragments and "unbound" particles. Of carbon-rich IDPs (>9-19 µm) ~70% occurred in clusters. There are no "unbound" carbon-rich IDPs > 19 µm.

TABLE 1: AVERAGE CLUSTER IDP CONSTITUENTS. DIMENSIONS ARE IN MICRONS.

	mean	range	*N*	mean	range	*N*
CP IDPs	6.8	3.4–9.4	12	not present		
CF IDPs*	4.7	2.2–6.9	64	8.8	7.2–12.0	27
Ol/Pyrox	4.7	3.1–9.3	11	11.9**		
FeS	3.5	2.8–4.7	7	not present		

*Only carbon-rich IDP U2022G1 is >19 µm; **U2015C7, a plagioclase(?) grain (11.9 µm)

I do not anticipate large pyrometamorphic differences among the fragments of a cluster IDP due to atmospheric entry flash heating. About 16% of fragments (2-9 µm) and 9% of fragments (>9-19 µm) show heating effects [for criteria *cf*. ref. 1]. In the size range of 2-9 µm, the average carbon-rich fragment is 5.2 µm (range: 2.5-7.2; *N*=16) while the average low-carbon fragment is 6.4 µm (range: 2.8-9.1; *N*=5). These data show that the carbon content is not unique to determine the thermal survival of the fragments in cluster particles. Carbon-rich IDP U2001E15 (1.9 µm) is the smallest "unbound" IDP that survived flash heating. It constrains the collector cut-off size. Smaller IDPs reached the collectors as a cluster. The high incidences of IDPs 1-5 µm on three collectors [4] are circumstantial evidence for fragmentation during or just prior to impact of cluster IDPs and volcanic clusters onto the collectors. The unmelted carbon-rich CP IDP W7029B10 (3.1 µm) represents an unrecognised cluster that would lower the abundances of "unbound" IDPs < 9 µm on this collector *(cf*. Figure 1).

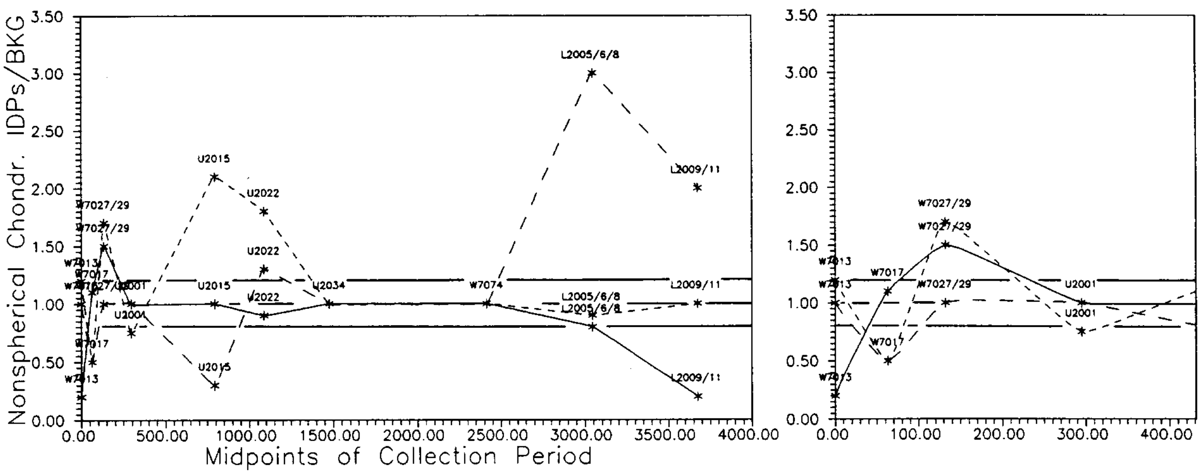

FIGURE 1: Normalized abundances of "unbound" nonspherical chondritic IDPs [2-9 µm: solid line; >9-19 µm: fine dashed line] on collectors that sampled the lower stratosphere between 22 May, 1981 to 11 July, 1991, as well as cluster IDPs (assumed to be > 19 µm (coarse dashed line), as a function of the midpoints of the collection period for each collector whereby the first day is May 22, 1981. The horizontal lines indicate the background % 20%. The lines connecting individual collectors merely serve to guide the eye but CANNOT be used to define continuous trends in these IDP abundances.

CONCLUSIONS. A statistical survey of nonspherical chondritic IDPs from the NASA/JSC Cosmic Dust Catalogs constrain the petrological types and proportions of fragments of an *average chondritic cluster IDP*, (i) chondritic IDPs, (ii) Fe,Mg,Ca-silicates and (iii) FeS particles, as a function of fragment size. A similar make-up, *i.e.* principal components, silicates and Fe,Ni-sulfides characterises fragment L2011A9 [5] from cluster L2011#4. Cluster IDPs may have a similar fundamental make-up as their large fragments suggesting a hierarchy of building blocks. Calcium in chondritic IDP is probably due to pigeonite and diopside [6,7] inclusions (Table 1). Variations in CP to CF fragments determine the tensile strength of cluster IDPs which is biased against large coherent units. Particles >19 µm on the collectors are likely to be volcanic ash instead of solar nebula aggregates. The steady supply of "unbound' nonspherical chondritic IDPs < 19 µm to the lower stratosphere might be linked to the meteoroid flux of this size. Fluctuation relative to the BKG levels may possibly support streams of cluster IDPs. The incidence of cluster IDPs on the LACs found by this survey provides support for annual events of unique IDPs with high $^{3}He/^{4}He$ [8] and high D/H ratios [Flynn, 1996, pers. comm.].

REFERENCES: [1] Rietmeijer FJM (1997) LPS **XXVIII**, companion abstr.; [2] Thomas K *et al*. (1995) GCA **59**, 2797-2815; [3] Rietmeijer FJM & Warren JL (1994) AIP Conf. Proc. **310**, 255-275; [4] Zolensky ME *et al*. (1989) JGR **94(D1)**, 1047-1056; [5] Rietmeijer FJM (1994) AIP Conf. Proc. **310**, 231-240; [6] Zolensky ME & Barrett R (1994) Meteoritics **29**, 616-620; [7] Rietmeijer FJM (1995) LPS **XXVI**, 1165-1166; [8] Nier AO & Schlutter DJ (1993) Meteoritics 28, 675-681. This work was supported by NASA Grant NAGW-3626.